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Supreme Court, U.S.
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No. _____

In The

Supreme Court of the United States

October Term, 1988

DANA CORPORATION,

Petitioner,

vs

IPC LIMITED PARTNERSHIP
and
INTERNATIONAL PACKINGS CORPORATION,

Respondents.

PETITION FOR A WRIT OF CERTIORARI TO THE UNITED STATES COURT OF APPEALS FOR THE FEDERAL CIRCUIT

– AND APPENDICES –

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QUESTION PRESENTED

SEVENTH AMENDMENT RIGHT TO TRIAL BY JURY

There was substantial evidence to support the jury's implicit finding that polyacrylic was the best mode of practicing this invention. The Federal Circuit reversed that jury finding, ignoring the record below by failing to even mention the polyacrylic evidence, thereby creating a new fact record. The question presented is whether the Federal Circuit's entry of JNOV denied Dana its Seventh Amendment right to trial by jury.

DESIGNATION OF CORPORATE AFFILIATIONS

Dana Corporation's affiliates and subsidiaries (other than wholly owned subsidiaries) are Hayes Dana, Inc.; Spicer, SA; Manufacturas Victor Gaskets de Columbia, SA; Industria De Ejes 4 Transmissiones SA (Transejes); Dana Australia (Holdings) Ltd.; Albarus, S.A.; E. Daneri, I.C.S.A.; Danargen, S.A.I.C.; Kelsey-Hayes de Mexico, S.A.; Floquet Monopole, S.A.; ROC Spicer, Ltd.; Mahindra & Mahindra, Ltd. (India); Koshine – Racine, Ltd.; Elastomatic Actuators, Inc.; Wichita Company Limited; T.I. Interlock Limited; and Metalmecanica Consolidada, C.A.

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PETITION FOR A WRIT OF CERTIORARI TO THE UNITED STATES COURT OF APPEALS FOR THE FEDERAL CIRCUIT

Petitioner Dana Corporation respectfully prays that a Writ of Certiorari issue to review the Judgment and Opinion of the United States Court of Appeals for the Federal Circuit entered October 26, 1988.

OPINIONS BELOW

The Opinion of the United States Court of Appeals for the Federal Circuit is reported at 860 F.2d 415. (A-1 – A-10). The Opinion by the United States District Court for the Eastern District of Michigan on IPC's motion for JNOV was not reported. (B-1 – B-10).

JURISDICTION

The Judgment of the Federal Circuit was entered on October 26, 1988. (C-1). A timely Petition For Rehearing was denied on December 6, 1988, and this Petition For Certiorari was filed within 90 days of that date. The

Federal Circuit Order denying rehearing is reproduced in the Appendix. (D-1). This Court's jurisdiction is invoked under 28 U.S.C. § 1254(1).

SEVENTH AMENDMENT OF THE U.S. CONSTITUTION

The Seventh Amendment to the U.S. Constitution provides:

> In suits at common law, where the value in controversy shall exceed twenty dollars, the right of trial by jury shall be preserved, and no fact tried by a jury, shall be otherwise re-examined in any court of the United States, than according to the rules of the common law.

STATEMENT OF THE CASE

Dana sued IPC for infringement of U.S. Patent No. 3,498,621 in the United States District Court for the Eastern District of Michigan. The '621 patent issued for a threaded rubber valve stem seal used in automotive engines. In summary, the valve stem seal of the '621 patent is a rubber (elastomeric) grommet fitted onto the valve guide within which the valve stem reciprocates. The novel feature of the patented valve stem seal was the screw thread in the internal wall that contacts the valve stem.[1] Dana's design reduced oil consumption and was first used in the Chevrolet Vega and Ford Pinto.

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[1] Claim 1 of the '621 patent reads:

> 1. In an internal combustion engine having a valve guide and a poppet valve stem mounted for reciprocating

(*Concluded on page 3*)

The case was tried to a jury from May 5-20, 1987. The jury returned a verdict in Dana's favor and Judgment was entered on the verdict July 21, 1987. IPC filed five motions for JNOV which were denied December 7, 1987.

A.

IPC's BEST MODE DEFENSE

One of IPC's defenses was that Dana failed to comply with the best mode requirement of 35 U.S.C. § 112, reproduced immediately below:

> The specification shall contain a written description of the invention, and of the manner and process of making and using it, in such full, clear, concise, and exact terms as to enable any person skilled in the art to which it pertains, or with which it is most nearly connected, to make and use the same, and shall set forth the best mode contemplated by the inventor of carrying out his invention.

(*Continued from page 2*)

axial movement in said valve guide, a valve stem seal for sealing between said valve stem and said valve guide, comprising a transversely extending portion of elastomeric material positioned atop said valve guide, said elastomeric portion having an axially extending receiving opening axially aligned with said valve guide and defined by an internal cylindrical wall, said internal wall having a diameter less than the diameter of said stem and having a screw thread formed therein, said screw thread being continuous and extending the full axial length of said internal wall, a depending annular elastomeric skirt integral with said elastomeric portion at the periphery thereof, said skirt being adapted to snugly surround said valve guide, means for radially inwardly biasing said transversely extending portion and means for radially inwardly biasing said annular skirt.

B.

BEST MODE COMPLIANCE IS A QUESTION OF FACT

Compliance with the best mode requirement of 35 U.S.C. § 112 is a question of fact. 860 F.2d at 418. (A-5).

C.

THE BEST MODE FACTUAL INQUIRY IS TWO-FOLD:
(1) WHAT IS THE BEST MODE, AND
(2) WAS IT CONCEALED?

The language of the statute, quoted above, required determination by the jury whether fluoride treated Buna-N or polyacrylic was the best mode. To sustain the best mode defense, the accused infringer must prove that the best mode was "concealed."

The jury instruction included 35 U.S.C. § 112, and the following instruction on "concealment":

> Under the patent law, the specification must set forth the best mode contemplated by the inventor of carrying out his invention without concealing from the public preferred products of his invention which he in fact conceived. In attempting to show non-compliance with the best mode requirement, only evidence of concealment (accidental or intentional) is to be considered.

The "concealment" requirement was affirmed by the Federal Circuit as controlling law:

> Whether or not a specific disclosure is adequate for best mode purposes is determined by comparing the disclosure with the facts concerning the invention known to the inventor at the time the application was filed. *Spectra Physics, Inc.* v. *Coherent, Inc.*, 827 F.2d 1524, 1535, 3 U.S.P.Q.2d 1737, 1745 (Fed. Cir. 1987).

> Since "there is no objective standard by which to judge the adequacy of a best mode disclosure, . . . only evidence of 'concealment', whether accidental or intentional, is considered." *Id. See also DeGeorge* v. *Burnier*, 768 F.2d 1318, 1324, 226 U.S.P.Q. 758, 763 (Fed. Cir. 1985); *In re Sherwood*, 613 F.2d 809, 816, 204 U.S.P.Q. 537, 544 (C.C.P.A. 1980). "Compliance with the best mode requirement exists when an inventor discloses his preferred embodiment." *In re Gay*, 309 F.2d at 772, 135 U.S.P.Q. at 315.
>
> 860 F.2d at 418. (A-5 – A-6).

D.

THE TRIAL RECORD ON THE BEST MODE ISSUE CONTAINS EVIDENCE ON: (1) BUNA-N *vs.* POLYACRYLIC, AND (2) CONCEALMENT

The trial record contained substantial evidence on the best mode contemplated by the inventor for the valve stem seal of the '621 patent. The best mode fact dispute was confined to the valve stem seal material. Exemplary documents reflecting the factual proofs at trial are reproduced in the attached Appendix. (Appendices E-H).

1. The Record On Fluoride Treated Buna-N *vs.* Polyacrylic

IPC relied upon a two-page test report by Wilson, the inventor, documenting bench tests conducted in 1963 for fluoride treated and untreated Buna-N rubber seals with various seal surface geometries. The Wilson test report was dated November 2, 1964. IPC argued that the statement in this Wilson test report that "fluoride treatment was necessary" proved that fluoride treatment was the best mode.

Dana countered with a memorandum signed by the inventor Wilson *on the same day as the test report* which states:

> Buna N rubber is restricted to service temperatures which do not exceed 250°F and, because of its composition, it is subject to deterioration from heat aging. It can be teflon spray coated or the compound can be modified by additional graphite or it can be fluoride surface treated. The latter treatment is to be preferred.
>
> Polyacrylic rubber has a service temperature of about 325°F although we are experimenting with a compound capable of withstanding 400°F. Its composition is entirely different from Buna N and is much less susceptible to heat aging deterioration. It likewise can be teflon spray coated and can be compounded with additional graphite for lubrication and subsequently tumbled in moly disulfide. This latter is the preferred treatment. It cannot be fluoride surface treated.

(Appendix E, ¶¶ 2 and 3; E-1).

Buna-N — acrylonitrile-butadiene — is disclosed in the '621 patent, but fluoride treatment was not specifically disclosed. IPC argued that the absence of disclosure of fluoride treatment invalidated the '621 patent under 35 U.S.C. § 112.

The jury had a substantial basis to find that polyacrylic was the best mode.[2] The preferred treatment of

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[2] In addition to the report quoted above, Wilson also prepared a test report of February 17, 1965 comparing Buna-N and polyacrylic valve stem seals. Wilson concluded in that report that polyacrylic appeared to give improved performance compared to Buna-N. (F-1 – F-2). Wilson again noted that polyacrylic "was a higher temperature resistant replacement for the [Buna-N]" — an important factor for automotive engine components.

polyacrylic was fully disclosed in the '621 patent.[3] The inventor's reports showed that polyacrylic rubber was superior to Buna-N rubber in two important ways — higher temperature resistance and less susceptibility to heat aging deterioration.

The '621 patent application was filed on June 14, 1965. Subsequently, the inventor Wilson prepared a summary of the valve guide seal development — dated January 26, 1967. (G-1–G-10). Of particular importance is his conclusion echoing his earlier report on the superiority of polyacrylic over Buna-N:

> Polyacrylic (high modulus) all rubber seals operated 50,000 miles and provided consistent control of valve oil consumption during this mileage. Buna-N all rubber seals likewise operated 50,000 miles but did not provide a uniform level of oil control throughout the test.

2. The Concealment Issue

Mr. Dega, Dana's expert on seal technology based on 38 years' seal experience at General Motors Corporation,

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[3] Polyacrylic is fully disclosed in the '621 patent, including the details of the preferred surface treatments used by Dana. The text of the '621 specification on materials and treatments reads:

> The valve seals 42 of this invention have at least the sealing portion 46 made of elastomeric material, and particularly good results have been obtained from seals made of acrylonitrile, butadiene, and polyacrylics rubbers and combinations thereof. These are well known materials which are widely used in internal combustion engines for sealing purposes. In some instances the sliding, sealing surfaces, such as the internal wall 50, may be coated with a lubricating material, such as molybdenum disulfide, graphite, or the like, to provide a more slippery surface on the elastomeric material and decrease friction between the seal 42 and the valve stem 26. The methods of applying such surface coatings are well known and widely used for elastomeric seals.

testified at trial that those knowledgeable with valve stem seals were well aware by 1965 of the fluoride treatment process and its benefits when applied to Buna-N used as a seal material. Dana also introduced an article on fluoridation published in 1961. (H-1 – H-9). In addition, Dana proved that the fluoride treated Buna-N used by Dana was supplied by a vendor, who recommended it to Dana as a seal material. Dana contributed nothing to this treatment technique. These were Dana's proofs to negate concealment *if* the jury found that fluoride treated Buna-N was the best mode — IPC argued, but offered no further evidence on, concealment.

E.

THE FEDERAL CIRCUIT ENTRY OF JNOV

The Federal Circuit reversed the Judgment against IPC, granting JNOV on the best mode defense, on the following findings — ignoring all evidence on polyacrylic and concealment:

> The "Wilson report," the in-house letter cited above, and the testimony concerning Dana's first sales of the patented seals are the *only* pieces of evidence in the record that are probative concerning what the inventor, Mr. Wilson, thought constituted the best mode of his invention. The two documents present uncontroverted and corroborating evidence that, at the time the application for the '621 patent was filed, Mr. Wilson believed that the best way of carrying out his invention included fluoride treating the surface of the valve seals. That this was the best mode at the time is confirmed by the fluoride treated seals based on the Wilson design first sold by Dana. Having *no evidence* to the contrary to consider, reasonable minds could not have dif-

> fered as to whether Mr. Wilson believed that fluoride surface treatment was part of the best mode of carrying out the claimed invention.
>
> 860 F.2d at 419-20 [emphasis added]. (A-9).

ARGUMENT

At trial, the jury implicitly found that polyacrylic was the best mode or that IPC failed to prove concealment, or both. These implicit findings are inherent to the rejection of IPC's best mode defense. The Federal Circuit ignored both of these fact findings and the record in support.

The Seventh Amendment forbids appellate courts from reexamining or redetermining facts found by the jury. *Atlantic & Gulf Stevedores, Inc.* v. *Ellerman Lines, Ltd.*, 369 U.S. 355; 82 S.Ct. 780 (1962). The Federal Circuit's de novo fact findings so far depart from the accepted and usual course of judicial proceedings as to call for an exercise of this Court's power of supervision.

The Federal Circuit did not "(1) consider all the evidence, (2) in a light most favorable to the non-mover; (3) drawing reasonable inferences favorable to the non-mover; (4) without determining credibility of witnesses, and (5) without substituting its choice for that of the jury between conflicting elements in the evidence" as it acknowledged it was required to do at 860 F.2d 417. (A-4)

If the Federal Circuit had applied the law as stated in its Opinion, affirmance would have followed independently (1) from the substantial evidence before the jury that polyacrylic was thought by Wilson to be superior to Buna-N, *i.e.*, polyacrylic was the best mode, and (2) from Dana's evidence negating concealment of the fluoride treatment of Buna-N.

A.

FLUORIDE TREATED BUNA-N *vs.* POLYACRYLIC

Nowhere does the Federal Circuit acknowledge the record facts regarding Wilson's investigation of polyacrylic. Consequently the Federal Circuit does not address the jury's implicit fact findings that polyacrylic, as recorded by Wilson both before and after the '621 application was filed, was superior to Buna-N, *i.e.*, polyacrylic was the best mode.

The inference the Federal Circuit drew from the "Wilson report" of November 2, 1964 is contradicted by the "Wilson report" of February 17, 1965 — concluding polyacrylic was a replacement for Buna-N that gave improved performance. The latter report was before the jury on this vigorously litigated issue, but ignored by the Federal Circuit. Additionally, the Federal Circuit's inference regarding Buna-N from "Dana's first sales of the patented seals" after the filing date of the '621 application, 860 F.2d 420 (A-9), is contradicted by the January 26, 1967 development summary authored by Mr. Wilson, where he reports superior performance results for polyacrylic compared to Buna-N.

The jury's implicit fact findings on polyacrylic *versus* Buna-N are ignored by the Federal Circuit.

B.

CONCEALMENT

Inexplicably, the Federal Circuit states, but does not apply, the law of concealment.

The jury's implicit "concealment" fact findings are not contradicted by the Federal Circuit — they stand.

C.

CONCLUSION: THE FEDERAL CIRCUIT IMPROPERLY REDETERMINED THE FACTS

The Federal Circuit violated the Seventh Amendment by redetermining the facts in a de novo opinion, ignoring substantial evidence supporting the jury verdict, and all evidence on the implicit findings on polyacrylic and concealment. The Federal Circuit Opinion is contrary to *Atlantic & Gulf Stevedores, Inc.* v. *Ellerman Lines, Ltd.*, 369 U.S. 355; 82 S.Ct. 780 (1962):

> We might agree with the Court of Appeals had the questions of fact been left to us. But neither we nor the Court of Appeals can redetermine facts found by the jury any more than the District Court can predetermine them. For the Seventh Amendment says that "no fact tried by a jury, shall be otherwise reexamined in any Court of the United States, than according to the rules of the common law."
>
> 369 U.S. at 358-9.

Dana was denied its right to a jury trial by the Federal Circuit.

CONCLUSION

Exercise of this Court's power of supervision is required to conform Federal Circuit JNOV practice with long-settled precedent under the Seventh Amendment.

Accordingly, the Writ of Certiorari should issue to review the Judgment and Opinion of the Federal Circuit in this case.

Respectfully submitted,

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Dated: March 3, 1989

APPENDICES TO PETITION FOR CERTIORARI

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APPENDIX A

OPINION

(United States Court of Appeals — Federal Circuit)

(October 26, 1988)

(DANA CORPORATION, Plaintiff-Appellee, v. IPC LIMITED PARTNERSHIP and International Packing[s] Corp., Defendants-Appellants — No. 88-1194; *Reported at:* 860 F.2d 415 (1988))

Before: ARCHER and MICHEL, Circuit Judges, and SKELTON, Senior Circuit Judge.

ARCHER, Circuit Judge.

IPC Limited Partnership and International Packing Corp. (IPC) appeal from the judgment of the United States District Court for the Eastern District of Michigan, holding U.S. Patent 3,498,621 ('621) owned by Dana Corporation (Dana) valid, enforceable and willfully infringed by IPC and awarding damages to Dana.[1] We reverse.

BACKGROUND

The '621 patent, entitled "Valve Stem Seal," issued to R. R. Wilson in 1970 and was assigned to Dana. Dana manufactures and sells the valve stem seals to auto-

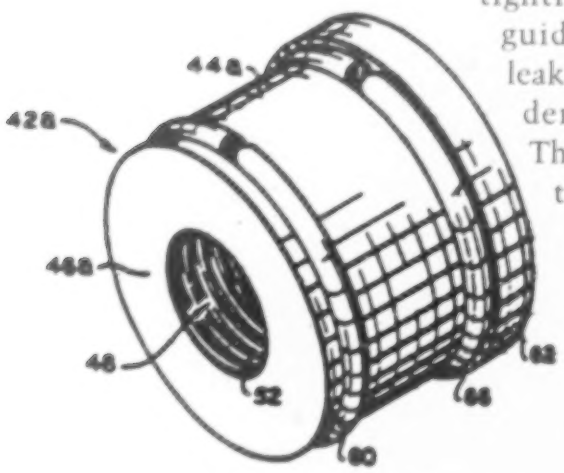
[1] Prior to trying the case on the merits, the district court granted IPC's motion for summary judgment based on laches to the extent that Dana was barred from recovering any pre-suit damages. That decision has not been appealed.

mobile manufacturers, including General Motors Corporation (GM), for use in the manufacture of automobile engines.

Claim 1 of the '621 patent recites, in part:

> In an internal combustion engine having a valve guide and a poppet valve stem, . . . a valve stem seal for sealing between said valve stem and said valve guide, comprising a transversely extending portion of elastometric [*sic*] material positioned atop said valve guide . . . ."

The seal, shown in the following figure from the patent, is composed of an elastomeric material and fits tightly atop the valve guide to prevent oil leakage into the cylinders of the engine. The central cavity of the seal, through which the valve stem extends during use, is defined by walls purposefully scored with threads to permit sufficient oil to remain between the valve stem and the seal. The presence of this controlled amount of oil is necessary to lubricate the reciprocating movement between the stem and the seal.



In the mid-1970's, both Dana and IPC began manufacturing and selling valve stem seals to GM, Dana supplying seals under the rights of the '621 patent and IPC supplying seals according to GM's design specification. In accordance with GM's policy, the Dana-GM sales

agreement gave GM the right to "second-source" the patented seal, i.e., to seek another vendor to supply GM with Dana's patented seals so long as GM continued to purchase 60% of its seal requirements from Dana. The valve stem seal produced by IPC according to GM's specification is identical to that described in claim 1 of the '621 patent.

In January 1986, Dana filed suit against IPC for infringement of claim 1 of the '621 patent.[2] Although the parties disagree as to which theory of infringement, direct or contributory, was originally pled, the case was tried, over IPC's objection, under 35 U.S.C. § 271(c), contributory infringement. Dana additionally sought increased damages for willful infringement under 35 U.S.C. § 284.

One of the bases on which IPC defended the suit was that the patent was invalid for failure to disclose best mode, *see* 35 U.S.C. § 112, first paragraph, in that Dana did not identify the fluoride surface treatment of the seals, which Mr. Wilson knew was the best mode of carrying out his invention at the time the application was filed.

The district court, on the basis of a general jury verdict, held the '621 patent to be valid, enforceable and willfully infringed by IPC.

IPC filed five motions for judgment notwithstanding the verdict (JNOV) or, in the alternative, for a new trial. One of the five JNOV motions was based upon best mode invalidity. The trial court denied each of these JNOV motions, including the requested new trial, in a Memorandum Opinion and Order dated December 7, 1987. IPC appeals from the Judgment and Order of the

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[2] The testimony indicates that suit was filed after GM ceased buying seals from Dana.

district court, assigning as error, *inter alia*, the denial of the JNOV motion based on best mode invalidity. Since we hold that the '621 patent is invalid for failure to disclose best mode, it is not necessary to consider IPC's other grounds for appeal.

OPINION

[A] *STANDARD OF REVIEW*

In considering a motion JNOV the trial court must determine (1) whether there is substantial evidence to support the jury's findings and (2) whether those findings are legally sufficient to support the legal conclusion drawn by the jury in reaching its verdict. *Railroad Dynamics, Inc.* v. *Stucki Co.*, 727 F.2d 1506, 1513, 220 USPQ 929, 936 (Fed. Cir.1984). "Substantial" evidence, as required by the first step, is such relevant evidence, taken from the record as a whole, "as might be accepted by a reasonable mind as adequate to support the finding under review." *Perkin-Elmer Corp.* v. *Computervision Corp.*, 732 F.2d 888, 893, 221 USPQ 669, 673 (Fed.Cir.), *cert. denied*, 469 U.S. 857, 105 S.Ct. 187, 83 L.Ed.2d 120 (1984). In reviewing the evidence "a court must: (1) consider all the evidence, (2) in a light most favorable to the non-mover; (3) drawing reasonable inferences favorable to the non-mover; (4) without determining credibility of witnesses, and (5) without substituting its choice for that of the jury between conflicting elements in the evidence." *Connell* v. *Sears Roebuck & Co.*, 722 F.2d 1542, 1546, 220 USPQ 193, 197 (Fed.Cir.1983); *McGill Inc.* v. *John Zink Co.*, 736 F.2d 666, 672, 221 USPQ 944, 948 (Fed.Cir.), *cert. denied*, 469 U.S. 1037, 105 S.Ct. 514, 83 L.Ed.2d 404 (1984). *See also Morelock* v. *NCR Corp.*, 586 F.2d 1096, 1104-1105 (6th Cir.1978). The second step allows the trial court to avoid "a miscarriage of justice by reach-

ing, when the rules render it necessary, a legal conclusion different from that of the jury." *Railroad Dynamics, Inc.* v. *Stucki Co.*, 727 F.2d at 1513, 220 USPQ at 936.

Since each of the determinations discussed above is a question of law, *McGill Inc.* v. *John Zink Co.*, 736 F.2d at 672, 221 USPQ at 948, we are governed by the same standard on review. As such, a party seeking reversal of grant or denial of a motion JNOV must convince this court that the trial court erroneously applied one or both of these steps. *Unidisco Inc.* v. *Schattner*, 824 F.2d 965, 967, 3 USPQ2d 1439, 1441 (Fed.Cir.1987), *cert. denied*, — U.S. —, 108 S.Ct. 774, 98 L.Ed.2d 860 (1988); *D.M.I., Inc.* v. *Deere & Co.*, 802 F.2d 421, 425, 231 USPQ 276, 278 (Fed.Cir.1986).

(B) *BEST MODE*

[1] The pertinent part of 35 U.S.C. § 112, first paragraph, requires that "[t]he specification . . . set forth the best mode contemplated by the inventor of carrying out the invention". Best mode is a question of fact. *McGill, Inc.* v. *John Zink Co.*, 736 F.2d at 676, 221 USPQ at 951. The purpose of the best mode requirement is to ensure that the public, in exchange for the rights given the inventor under the patent laws, obtains from the inventor a full disclosure of the preferred embodiment of the invention. *In re Gay*, 309 F.2d 769, 772, 50 CCPA 725, 135 USPQ 311, 315 (1962).

[2] Whether or not a specific disclosure is adequate for best mode purposes is determined by comparing the disclosure with the facts concerning the invention known to the inventor at the time the application was filed. *Spectra-Physics, Inc.* v. *Coherent, Inc.*, 827 F.2d 1524, 1535, 3 USPQ2d 1737, 1745 (Fed.Cir.1987). Since "there is no objective standard by which to judge the

adequacy of a best mode disclosure, . . . only evidence of 'concealment', whether accidental or intentional, is considered." *Id. See also DeGeorge* v. *Bernier*, 768 F.2d 1318, 1324, 226 USPQ 758, 763 (Fed.Cir.1985); *In re Sherwood*, 613 F.2d 809, 816, 204 USPQ 537, 544 (CCPA 1980). "Compliance with the best mode requirement exists when an inventor discloses his preferred embodiment." *In re Gay*, 309 F.2d at 772, 135 USPQ at 315.

[3] Concerning its best mode JNOV motion, IPC referred to what has been called the "Wilson report" to support its view that the best mode requirement had not been complied with. This document, dated November 16, 1964 (approximately seven months before the filing date of the application), is a test report documenting tests the stated objective of which was "[t]o investigate and determine which design is most effective in controlling leakage and what is the effect of the surface treatment". The test included comparing the effectiveness of five different seal designs,[3] each design being tested both with and without a 60-second fluoride surface treatment. The test conclusions, signed by the inventor, are as follows:

> No design was acceptable (max. allowable leakage = 0.75 gm/hr, preferred less than 0.5 gm/hr) when using non-treated rubber. Two designs (409-111F and 409-111H) were quite acceptable at leakage control *with fluoride surface treatment. Surface treatment is necessary to satisfactory performance of seal.* Engine test samples to be ordered from 409-111F and 409-111H designs with fluoride treatment. (Emphasis added.)

[3] The five designs employed in the test differed from one another by the geometry of the threads or grooves in the opening of the seal.

In addition, IPC pointed to a letter from the inventor's supervisor to Dana's patent counsel indicating that, upon seeing a draft of the application, Mr. Wilson "raised the point that no reference was made to fluoride treated rubber" in the disclosure. Although the same letter indicated that the disclosure of the fluoride treatment was omitted because Dana felt that it was "not part of the case," this was not further explained in the letter and we have been directed to no evidence at trial to show a basis for nondisclosure. Finally, the evidence establishes that the seals first sold by Dana were fluoride treated seals corresponding to the Wilson design.

Dana argued that the best mode requirement was satisfied because the "fluoride treatment of Buna-N rubber for seal applications was known to the public years before the filing date of the '621 patent application". A technical article from *Rubber Age* magazine and certain expert testimony was cited by Dana as supporting the view that such a treatment was common to the skilled artisan.

In the Memorandum Opinion, the district court concluded that the best mode requirement could be satisfied by reference to what the prior art discloses.[4] By reviewii g the jury's verdict under this erroneous view of the law, the district court erred as a matter of law. The best mode requirement is not satisfied by reference to the level of skill in the art, but entails a comparison of the facts known to the inventor regarding the invention at the time the application was filed and the disclosure in the specification. *Spectra-Physics, Inc.* v.

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[4] The opinion stated that, in order to deny IPC's motion, the court "need only find evidence to support [Dana's] position" that, as the court phrased it, "the flouridation [sic] of nitril rubber is well known to those of ordinary skill in the art."

Coherent, Inc., 827 F.2d at 1535, 3 USPQ2d at 1745. Indeed, in expressing this requirement, 35 U.S.C. § 112 states explicitly that disclosure must be made of the best mode "contemplated by the inventor." Accordingly, Dana's argument that the best mode requirement may be met solely by reference to what was known in the prior art is incorrect.

Dana's citation of our opinion in *Spectra-Physics, Inc. v. Coherent, Inc.*, *id.*, does not aid its cause. There we distinguished the enablement requirement, which does consider the level of skill in the art, from the best mode requirement. We stated:

> The essence of the enablement requirement is that a specification shall disclose an invention in such a manner as will enable one skilled in the art to make and utilize it. *Separate and distinct* from enablement is the best mode requirement, the essence of which requires the inventor to disclose the best mode *contemplated by him*, as of the time he executes the application, of carrying out his invention.
>
> * * *
>
> Enablement looks to placing the subject matter of the claims generally in the possession of the public. If, however, the applicant develops specific instrumentalities or techniques which are recognized at the time of filing as the best way of carrying out the invention, then the best mode requirement imposes an obligation to disclose that information to the public as well. (Emphasis in original.)

Id. at 1532, 3 USPQ2d at 1742 (citing *In re Gay*, 309 F.2d 769, 772, 50 CCPA 725, 135 USPQ 311, 315 (1962)).

[4] Therefore, the trial court's denial of IPC's JNOV motion on best mode grounds cannot stand because it was based upon an incorrect interpretation of the law. Rather than remand this case for a proper application of the law, however, we are convinced there are sufficient established facts of record to exercise our discretion to determine the merits of IPC's JNOV motion. 5A Moore's Federal Practice ¶ 50.12 (2d ed. 1983). *See Sjolund* v. *Musland*, 847 F.2d 1573, 1576, 6 USPQ2d 2020, 2023 (Fed.Cir.1988); *Verdegaal Bros., Inc.* v. *Union Oil Co. of Cal.*, 814 F.2d 628, 2 USPQ2d 1051 (Fed.Cir.1987). As noted, our review is based upon the same standard that is applicable in the district court. In order to grant IPC's JNOV motion we must determine as a matter of law that, upon the evidence presented at trial, reasonable minds could not have found that the best mode requirement was satisfied. *Morelock* v. *NCR Corp.*, 586 F.2d at 1104-1105.

The "Wilson report," the in-house letter cited above, and the testimony concerning Dana's first sales of the patented seals are the only pieces of evidence in the record that are probative concerning what the inventor, Mr. Wilson, thought constituted the best mode of his invention. The two documents present uncontroverted and corroborating evidence that, at the time the application for the '621 patent was filed, Mr. Wilson believed that the best way of carrying out his invention included fluoride treating the surface of the valve seals. That this was the best mode at the time is confirmed by the fluoride-treated seals based on the Wilson design first sold by Dana. Having no evidence to the contrary to consider, reasonable minds could not have differed as to whether Mr. Wilson believed that fluoride surface treatment was part of the best mode of carrying out the claimed invention.

Other surface treatments were set out in the specification as useful "in some instances" [5] as follows:

> In some instances, the sliding sealing surfaces, such as the internal wall, may be coated with a lubricating material, such as molybdenum disulfide, graphite, or the like, to provide a more slippery surface on the elastomeric material and decrease friction between the seal and the valve stem. The methods of applying such surface coatings are well known and widely used for elastomeric seals.

Nowhere in the specification, however, does the inventor disclose that a fluoride treatment must or even should be applied to the surface of the patented seals as indicated in the "Wilson report".

The established facts clearly show that fluoride surface treatment was the best mode contemplated by the inventor at the time the application for the '621 patent was filed, and that it was not disclosed in the specification. Since the '621 disclosure did not satisfy the best mode requirement of 35 U.S.C. § 112, first paragraph, IPC's JNOV motion on best mode grounds should have been granted and the '621 patent declared invalid.

REVERSED.

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[5] As previously shown, the Wilson report concluded that "[s]urface treatment is necessary to satisfactory performance of seal."

APPENDIX B

MEMORANDUM OPINION AND ORDER

(United States District Court —
Eastern District of Michigan — Southern Division)

(Filed December 7, 1987)

(DANA CORPORATION, Plaintiff, vs. IPC LIMITED PARTNERSHIP, and INTERNATIONAL PACKINGS CORPORATION, Defendants — CASE NO. 86-CV-70231-DT; HONORABLE LAWRENCE P. ZATKOFF)

AT A SESSION of said Court, held in the United States Courthouse, in the City of Detroit, State of Michigan, on the 7th day of December, 1987.

PRESENT: THE HONORABLE LAWRENCE P. ZATKOFF,
UNITED STATES DISTRICT JUDGE.

On May 20, 1987, the jury returned a verdict in favor of the Plaintiff. Thereafter, the parties have filed several post-trial motions. After allowing sufficient time for both parties to present and brief their arguments, the Court will now dispose of the motions individually.

I.

CONTRIBUTORY INFRINGEMENT

Defendants have filed a motion for judgment notwithstanding the verdict (hereinafter "J.N.O.V.") on the issue of contributory infringement. Defendants argue that Plaintiff failed to allege in its Complaint that Defendants contributorily, rather than directly, infringed on Plaintiff's patent. Plaintiff responds that Defendants were fully apprised of the contributory

infringement claim throughout the pendency of this suit.

Plaintiff's Complaint alleges that Defendants violated 35 U.S.C. § 271. This statute permits civil suits for both direct and contributory infringement. Moreover, paragraph 9 of Plaintiff's Complaint asserts that Defendants manufactured and supplied valve stem seals to a third party in violation of Plaintiff's patent.

Based on the above, the Court finds that Defendants were fully apprised of the claim and thus no surprise nor prejudice occurred. Further, the evidence offered throughout the trial was directed toward contributory infringement. Therefore, Defendants' motion for J.N.O.V. on the issue of contributory infringement is DENIED.

II.

EQUITABLE ESTOPPEL

During the trial, Defendants asserted the defense of equitable estoppel. The jury was instructed as to this defense. Based on the verdict, it is clear the jury rejected this defense.

Defendants have now filed a motion for J.N.O.V. on the affirmative defense of equitable estoppel. As stated in *Perkin-Elmer Corp.* v. *Computervision Corp.*, 732 F.2d 888 (Fed. Cir. 1984):

> When a party moves for JNOV, the trial court must consider all the evidence in a light most favorable to the non-mover, must draw reasonable inferences favorable to the non-mover, must not determine credibility of witnesses, and must not substitute its choice for that of the jury between conflicting elements in the evidence.

To support a claim of estoppel, Defendants must show that they were misled by misrepresentations, affirmative acts of misconduct, or intentionally misleading silence by the Plaintiff. *MGA, Inc.* v. *Centri-Spray Corp.*, 1 U.S.P.Q. 2d 1308 (E.D. Mich. 1986). Plaintiff submitted evidence that Defendants were aware that they were infringing on Plaintiff's patent. Further, Plaintiff offered evidence that it informed Defendants of the infringement. "[W]here there is a long period of silence after a threat of enforcement, but not a threat of *immediate* enforcement, the patentee will not be estopped from bringing an enforcement action." *Id.* at 1312; *Watkins* v. *Northwestern Ohio Tractor Pullers Ass'n*, 630 F.2d 1155, 1160 (6th Cir. 1980). The Court finds ample evidence to support the jury's verdict and thus DENIES Defendants' motion for J.N.O.V. on the issue of equitable estoppel.

III.

PATENT CLAIMS 1 AND 2

Claim 1 of Plaintiff's Complaint alleged the Defendants directly, actively or contributorily infringed on Plaintiff's patent. Claim 2 asserted allegations of infringement. Defendants seek J.N.O.V. on both claims.

The issues of direct infringement and active inducement under Claim 1 were not presented to the jury. Instead, in open court, Plaintiff withdrew the claim after Defendants moved for a directed verdict. The Court granted the withdrawal of the claim. Defendants now request the Court to grant a J.N.O.V. on Claim 1.

Defendants assert that the jury *was* instructed on direct infringement. The Court read the following instructions to the jury:

> Dana has the burden of proving infringement by a preponderance of the evidence.
>
> A patent claim may be directly infringed either literally or by equivalence. Dana is asserting literal infringement of claim 1 of the '621 patent. By literal infringement the Court means the following: if claim 1 "reads on" the IPC valve stem seal then there is literal infringement. A claim "reads on" a device when the language of the claim, construed in light of the specification and the prior art, describes the accused device element for element. In other words, literal infringement here requires that IPC's accused valve stem seals embody every element of claim 1 of the Dana patent. If you find that IPC sold valve stem seals to Chevrolet and Pontiac knowing that such seals were especially made or especially adapted for use in an infringement of Dana's patent, and you further find that such seals are not staple articles or commodities of commerce suitable for substantial noninfringing use, then IPC is liable as a contributory infringer of the Dana patent.

As is clear from these instructions, the jury was informed that there must be a literal infringement before there is a finding of contributory infringement. The jury, however, *was not* instructed to find that Defendants directly infringed. Based on the record, the Court finds that there was no issue presented to the jury that Defendants directly infringed under Claim 1 and thus Defendants' motion for J.N.O.V. on Claim 1 is DENIED.

Further, Defendants' motion for J.N.O.V. as to Claim 2 is also DENIED. Claim 2 was not presented to the

jury. Thus, a motion for J.N.O.V. is fruitless since no judgment was ever entered as to Claim 2.

IV.

INEQUITABLE CONDUCT

Throughout this matter, Defendants have argued that Plaintiff's actions before the United States Patent Office prevented Plaintiff from asserting a claim for infringement. The issue of inequitable conduct was presented to the Court through Defendants' motion for summary judgment and was tried by the jury. In both situations, Defendants' claim was denied.

Defendants have now filed a motion for J.N.O.V. on the claim of inequitable conduct. Defendants argue that the facts clearly and convincingly support their position. A review of Defendants' and Plaintiff's motion and the trial testimony support the position that reasonable minds could find that Plaintiff had properly informed the patent office of all facts relating to its invention. Defendants' motion merely reassembles arguments previously made; those arguments attack the credibility of certain testimony but do not assert any facts which would justify reversing the verdict of the jury. Therefore, for the aforementioned reasons, Defendants' motion for J.N.O.V. on the claim of inequitable conduct is DENIED.

V.

BEST MODE

Defendants have motioned for J.N.O.V. as to its affirmative defense of best mode requirement. Defendants claimed throughout trial, and in this motion, that the flouride treatment used by Plaintiff in its patent should have been made known to the patent examiner. Plain-

tiff's response throughout this proceeding has been that the fluoridation of nitril rubber is well known to those of ordinary skill in the art.

The Court need only find evidence to support Plaintiff's position. The specifications disclosed to the patent officer regarding the patent-in-suit states:

> In some instances the sliding, sealing surfaces, such as the internal wall 50, may be coated with a lubricating material, such as molybdeum disulfide, graphite, or the like, to provide a more slippery surface . . .

Defendants argue that although Plaintiff did set forth two types of lubricants, it was under a duty to inform the patent office of the flouridation of nitril rubber.

Both parties rely on the language of *Spectra-Physics v. Coherent, Inc.*, Nos. 86-1114 and 86-1133 (Fed. Cir. August 17, 1987) to support their position. As stated by the *Spectra* Court:

> Thus, compliance with the best mode requirement focuses on a different matter than does compliance with the enablement requirement. Enablement looks to placing the subject matter of the claims generally in the possession of the public. If, however, the applicant develops specific instrumentalities or techniques which are recognized at the time of filing as the best way of carrying out the invention, then the best mode requirement imposes an obligation to disclose that information to the public as well.

Id., slip. op. at 15 (citations omitted). The appropriate question is not whether the treatment was disclosed at all, but whether it was adequately disclosed. *Id.*, slip. op. at 25. "Even though there may be a general refer-

ence to the best mode, the quality of the disclosure may be so poor as to effectively result in concealment." *Id.*

In this matter, the jury was instructed on Defendants' best mode defense. Evidence was offered by both parties on the factual issue of whether Plaintiff adequately disclosed the treatment used on its patent. The Court is not in a position to hold that reasonable minds would have found differently than the jury. Therefore, Defendants' motion for J.N.O.V. on the issue of best mode requirement is DENIED.

VI.

ALTER JUDGMENT

The Defendants have motioned this Court to alter or amend the judgment of this action pursuant to F.R.Civ.P. 59(e). The jury returned a verdict in this action against the Defendants in the amount of $970,000.00. After a review of this matter, the Court finds that the jury could reasonably have determined the amount of damages it awarded. Therefore, Defendants' motion to alter or amend is DENIED.

VII.

WILLFUL INFRINGEMENT

Plaintiff has motioned this Court to find willful infringement and to enter an order under 35 U.S.C. § 284 to treble the damages of this action. Defendants object to the entering of this Order.

Willful infringement occurs when it is shown by the totality of the circumstances that there was a deliberate purpose to infringe. *American Original Corp.* v. *Jenkins Food Corp.*, 774 F.2d 459 (Fed. Cir. 1983) *cert. denied* 106 S.Ct. 1197 (1986). To willfully infringe, one must

have knowledge of the infringement. *State Industries, Inc.* v. *A. O. Smith Corp.*, 751 F.2d 1116 (Fed. Cir. 1985). The factors to consider in determining whether Defendants willfully infringed include:

(1) did the infringer have knowledge of the patent;

(2) did the infringer seek legal advice regarding the possibility of infringement;

(3) was there an attempt to develop a non-infringing device, or was the product merely a copy;

(4) did the infringer willfully adopt the patent design with an offer to hold harmless or indemnify customers;

(5) did the infringer assert defenses in bad faith.

See *King Instrument Corp.* v. *Otari Corp.*, 767 F.2d 853 (Fed. Cir. 1983), *cert. denied* 106 S.Ct. 1197 (1986); *American Original Corp., supra, Central Soya Co.* v. *George A. Hormel and Co.*, 723 F.2d 1573 (Fed. Cir. 1983).

The facts of this case show that Defendants willfully infringed on Plaintiff's patent. The evidence shows that Defendants were aware of the patent, did not obtain a legal opinion regarding whether their product infringed upon Plaintiff's patent, and actively pursued the marketing of the infringing product. It is clear from the evidence and testimony presented in this action that Defendants actively disregarded Plaintiff's patent. *Paper Converting Machine Co.* v. *Magna-Graphics Co.*, 745 F.2d 11 (Fed. Cir. 1984); *H. M. Stickle* v. *Heublein, Inc.*, 716 F.2d 1550 (Fed. Cir. 1983).

Since the Court has found that Defendants have willfully infringed Plaintiff's patent, the Court may, in its discretion, increase damages up to three (3) times the jury's verdict. 35 U.S.C. § 284. After consideration of all

of the facts of this case, the Court hereby increases Plaintiff's damages an additional $970,000.00 pursuant to 35 U.S.C. § 284.

Plaintiff has also requested attorney fees. 35 U.S.C. § 285 authorizes the District Court to award attorney fees in exceptional cases. The Court may consider factors such as the closeness of the case, counsel's tactics, and the parties' conduct. *S. C. Johnson & Son, Inc.* v. *Carter-Wallace, Inc.*, 781 F.2d 198 (Fed. Cir. 1986). Once this Court has determined that willful infringement exists, the Court must express its findings as to whether this is an exceptional case or not. As noted in *S. C. Johnson, supra*, attorney fees are generally awarded when willful infringement has been proven. *Id.* at 200.

In finding that there was willful infringement, the Court holds it would be grossly unfair to require the Plaintiff to pay for its attorney fees. The action would not have been instituted had Defendants not infringed upon a valid patent. The uncontradicted evidence offered at trial was that Plaintiff indeed had filed for patent of its invention. Defendants did not argue that their product was dissimilar from Plaintiff's. Instead, Defendants' entire defense centered upon the propriety of Plaintiff's conduct at the patent office.

For these reasons, the Court finds that an award of attorney fees is warranted. Plaintiff is to present an itemized list of its attorneys' time, with legal support stating why they are entitled to a particular item.

Corollary to the trebling of damages, the Court finds that Plaintiffs are entitled to an award of prejudgment interest. *General Motors Corp.* v. *Devex Corp.*, 461 U.S. 648 (1983); 35 U.S.C. § 284. The Court holds that Plaintiff is entitled to the statutory rate as set by M.C.L.A. § 600.6013. *Lam, Inc.* v. *Johns-Manville Corp.*, 718 F.2d

1056 (Fed. Cir. 1983). The current rate is 12 percent per annum. The Complaint was filed on January 17, 1987. Applying the daily interest from the date of the Complaint until the date of Plaintiff's motion, the Court holds that Plaintiff is entitled to $160,087.80 in prejudgment interest.

VIII.

MOTION FOR COSTS

Plaintiff has motioned for payment of costs. Pursuant to a letter sent to this Court, the parties stipulated that if costs are awarded, Plaintiff is entitled to $5,000.00. After a review of this matter, the Court finds that the costs are proper under F.R.Civ.P. 54(b), and hereby AWARDS Plaintiff $5,000.00 in actual costs.

IT IS SO ORDERED.

/s/ LAWRENCE P. ZATKOFF
UNITED STATES DISTRICT JUDGE

(Certification Omitted)

APPENDIX C

OPINION ANNOUNCING JUDGMENT OF THE COURT

(United States Court of Appeals — Federal Circuit)

(Opinion filed and Judgment entered October 26, 1988)

(DANA CORPORATION, Plaintiff-Appellee, v. IPC LIMITED PARTNERSHIP and International Packing[s] Corp., Defendants-Appellants — No. 88-1194)

The attached opinion announcing the judgment of the court in your case was filed today. The judgment was also entered pursuant to Rule 36.

Costs may be recoverable under Rule 39 or as the court may have directed in the opinion. A party entitled to costs is provided with a form for that purpose with this notice. Costs when taxed are payable to the party awarded its costs. If costs are awarded to the government, they should be paid to the Treasurer of the United States. Payment should be made to counsel for the party awarded costs or, if the party is not represented by counsel, to the party pro se. Costs should be paid promptly.

If the court also imposed monetary sanctions, they are payable to the opposing party unless the court's opinion provides otherwise. Sanctions should be paid in the same way as costs.

FRANCIS X. GINDHART
Clerk

APPENDIX D

ORDER

(United States Court of Appeals — Federal Circuit)

(Filed December 6, 1988)

(DANA CORPORATION, Plaintiff-Appellee, v. IPC LIMITED PARTNERSHIP and INTERNATIONAL PACKINGS CORP., Defendants-Appellants — No. 88-1194)

Before: ARCHER and MICHEL, *Circuit Judges,* and SKELTON, *Senior Circuit Judge.*

A petition for rehearing having been filed in this case,

UPON CONSIDERATION THEREOF, it is

ORDERED that the petition for rehearing be, and same hereby is, denied.

The suggestion for rehearing in banc is under consideration.

FOR THE COURT

/s/ Francis X. Gindhart
Clerk

December 6, 1988

cc: R. V. Lupo
Ernie L. Brooks

Note: This Order will not be published in a printed volume because it does not add significantly to the body of law and is not of widespread legal interest. It is a public record. It is not citable as precedent.

APPENDIX E

MEMORANDUM

(November 2, 1964)

PERFECT CIRCLE Corporation Correspondence

TO: John Shirk *FROM:* Robert R. Wilson, Sr.
SUBJECT: PATENT DETAILS – ALL RUBBER VALVE SEALS
DATE: 11-2-64 MEMO# 26

Pursuant to the conversation between you, Bill Charlesworth, and myself, attached are copies of drawings ER 409-B111, 113, and 114 which describe the original five designs of all-rubber seals. Bench testing revealed that the designs 409-111F and 111H, which involve the use of a thread finish with lead, to be superior in performance to the other three designs. These drawings do not describe surface treatments or rubber compounding but they do reveal the use of the thread finish. All three drawings date back to February 1963.

Buna N rubber is restricted to service temperatures which do not exceed 250°F and, because of its composition, it is subject to deterioration from heat aging. It can be teflon spray coated or the compound can be modified by additional graphite, or it can be fluoride surface treated. The latter treatment is to be preferred.

Polyacrylic rubber has a service temperature of about 325°F although we are experimenting with a compound capable of withstanding 400°F. Its composition is entirely different from Buna N and is much less susceptible to heat aging deterioration. It likewise can be teflon spray coated and can be compounded with additional graphite for lubrication and subsequently tumbled

in moly disulfide. This latter is the preferred treatment. It cannot be fluoride surface treated.

Our Road Testing to date has involved treated Buna N jackets, polyacrylic with graphite addition in the compound, and polyacrylic with a teflon spray coating. Customer samples have been furnished in the first two designs.

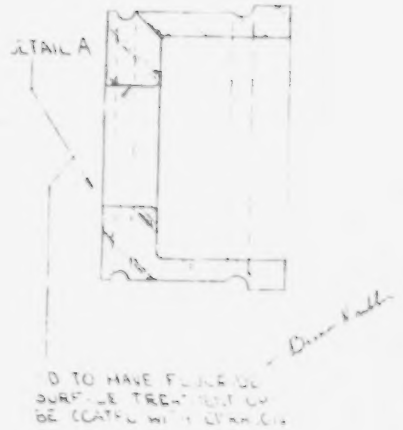
/s/ Bob
Robert R. Wilson, Sr.
Supervising Project Engineer
Research Department
ald

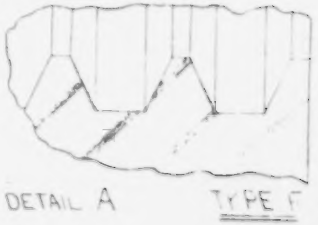
cc Bill Barbour

D.5

916

DO NOT SCALE DRAWING
TOLERANCE
DECIMAL DIMENSIONS ± .001
FRACTIONAL DIMENSIONS ± 1/64
UNLESS OTHERWISE SPECIFIED





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PERFECT CIRCLE CORP.
HAGERSTOWN, INDIANA

NAME
VALVE GUIDE SEAL

MATERIAL
110-92

SCALE

SHEETS 1 | SHEET # 1

E-525

APPENDIX F

TEST REPORT

(February 17, 1965)

PERFECT CIRCLE CORPORATION
RESEARCH DEPARTMENT

OBJECTIVE: To determine the performance level of four types of seals as a comparison of production design seals with jackets from different compounds and all rubber seals. Test to be used as a screening evaluation for future tests.

PROJECT FILE NOS.: 409-108 [*S108*]

PART IDENTIFICATION: Below

APPARATUS: 1964 AMC Rambler classic V-8 engine, 3¼" bore 287 cu. in.

SUMMARY:

Three sets of seals of each of four types were run for 24 hrs. per set in Engine Lab test #1096, completed 4-17-64.

Set Nos.	*Seal Description*	
2-1, 2-2, 2-3	1912, conventional design,	Buna rbr., Kitco comp'd 502
10-1, 10-2, 10-3	1912, " " ,	P.A. lower modulus, Kitco comp'd 9914-10
17-1, 17-2, 17-3	1912, " " ,	P.A. higher modulus, Kitco comp'd 9914-17
18-1, 18-2, 18-3	409-125 all rubber design,	#19 ring in top groove, P.A. addt'l graphite in compound, Kitco comp'd 9914-18

Each set of seals operated for a total of 8 hrs. at each of the following conditions: 1700 RPM – 14.9 HP, 2600 RPM – 35.1 HP, 3200 – WOT

The order of testing was randomized for all sets.

Numerical average of the stabilized average oil consumption for the seal types is:

	Sets		
2-1, 2-2, 2-3	10-1, 10-2, 10-3	17-1, 17-2, 17-3	18-1, 18-2, 18-3
Ave. .033 lb/hr.	.025 lb/hr.	.035 lb/hr.	.025 lb/hr.

CONCLUSIONS:

1) The 9914-10 comp'd which was a higher temperature resistant replacement for the 502 comp'd appeared to give improved performance, 2) the 9914-17 comp'd which was a stiffer material than 9914-10 comp'd and which was supposed to correct a customer problem of insert popout at initial engine hot test appeared to operate at the same level as the 502 comp'd, 3) the all rubber seal which was a cost reduced model for O.E.M. appeared to give improved performance over the conventional seal with the Buna jacket, 4) visual examination of the all rubber seals revealed wear of the internal grooving (thought to be excessive for short testing involved). Wear appeared to be concentrated in a certain portion of the periphery which indicated non-concentric O.D. and bore 5) on the basis of exhibiting the least wear of the internal grooving, set 18-1 was selected for indurance [*sic*] testing in test 1097, and 6) two new cylinder heads and two used heads were measured for concentricity of guide O.D. and bore with results of new heads average .014", used heads average .016" difference in guide wall thickness.

PROJECT ENGINEER: /s/ Robert R. Wilson, Sr.
DATE: 2-17-65 Form #2757

APPENDIX G

SUMMARY REPORT [*Sheet Nos. 1-8*]

(January 26, 1967)

VALVE GUIDE SEAL DEVELOPMENT

3-K-409-F023
2-K-757-F003

DATE: January 26, 1967

ABSTRACT:

This report records the results of the second two 50,000-mile endurance engine tests of all-rubber valve seals.

All-rubber seals made from both a Buna N and a high modulus Polyacrylic compound were operated in two 1965 Chevrolet 283 engines by Automotive Research Associates, San Antonio, Texas, for the above mileage. Original Equipment seals were operated 10,000 miles in both units for comparative purposes.

Both sets of seals operated for 50,000 miles. Seals produced from the Polyacrylic material provided the better oil control. Valve stem and guide wear was normal.

PURPOSE:

The purpose of this report is to record the results of the second two 50,000 mile engine tests of all-rubber valve seals which were run in cars operated by Automotive Research Associates, an independent firm at San Antonio, Texas.

The second two tests were run in the same engine as the first two tests, but new cylinder heads, new valves, new rings and new pistons were used. Seals

from a Buna N compound and from a lower modulus Polyacrylic compound were run in the first series of tests on rougher valve stem surfaces. Seals from the same Buna N compound and from a higher modulus Polyacrylic compound were run on the opposite engines from the first tests. In addition, valve stem surface finish was smoother for the second series of tests.

The results of the first series of tests were reported in report 757-F002-409-F020 dated November 1965.

CONCLUSIONS:

1. Polyacrylic (high modulus) all-rubber seals operated 50,000 miles and provided consistent control of valve oil consumption during this mileage. Buna N all-rubber seals likewise operated 50,000 miles but did not provide a uniform level of oil control throughout the test.

2. Guide and stem wear for both engines were normal for the mileage operated. Exhaust guide wear was slightly more for the engine on which Polyacrylic seals operated.

3. All-rubber seals reduced valve oil consumption more during the first half of these two tests.

4. Seals produced from a higher modulus Polyacrylic rubber compound provided better valve oil control than the same seals produced from a Buna N rubber compound. Some unaccountable adverse factor seriously affected the performance of the Buna N seals.

5. Hysteresis measurements for both groups of seals indicated a small increase for this characteristic from the new to used condition. The average

value for the Buna N seals was only very slightly more than for the Polyacrylic seals.

6. Installation of Original Equipment seals reduced the oil economy level for both units.

OBSERVATIONS & OPINIONS:

Figure 1* is a record of the oil economy for both ARA vehicles in miles per quart plotted at 10,000 mile intervals. Figure 2 is a record of the accumulated average oil economy for both ARA vehicles in miles per quart plotted directly from the information supplied by ARA. After the testing began, it was learned that a complete accounting for all the oil in the engine was not made at the oil changes between filter change intervals at 10,000 mile periods. Oil remaining in the engine, particularly in the filter, was reported as being consumed. Since the engines were completely exhausted of oil at the 10,000 mile filter changes, the calculation of oil economy is considered to be most accurate at these intervals as plotted in Figure 1.

From the running plot of the data as furnished by ARA (Figure 2), the trend of oil economy for unit #148 on which Buna N seals operated became questionable at the 30,000-mile interval. Inspection of the engine at 38,426 miles indicated three exhaust seals up off and loose from the guides. Replacement of these seals by new seals did not improve the economy as expected. Figure 3 illustrates a typical condition of some of the guides on which the original machined O.D. did not clean up when machined with the P.C. tool because of an eccentric condition between the O.D. and I.D. The condition was observed

* *All figures omitted in this reproduction.*

prior to the test but was adjudged to be insufficient to cause difficulty. Figures 4 through 7 reveal lateral and longitudinal guide wall measurements after testing for the four heads run in this second test series. Indication of the extent of the non-clean up is revealed by the angular displacements. It can be seen from Figure 4 that the difference between the diameters across the two machined surfaces of #6 intake and #8 exhaust guides appears to be rather excessive. It might be reasonable to expect that even .010" difference between the diameters of the two surfaces on some of the other guides might be sufficient to allow passage of oil between the guide and the seal particularly after some aging has occurred. The oil economy data would seem to support this theory. In addition, much less effort was required to remove the Buna N than the P.A. seals at the time of installation of OEM seals.

If the oil economy level for the last 10,000 miles (run with new OEM seals) as shown in Figure 2 is compared with the level of the same engines in the first series of tests (Figure 1, report 757-F002, 409-F020), it can be seen that a basic difference existed between the two engines with the #145 unit operating at the higher level during this portion of each test series. The magnitude of this difference, however, was considerably greater in the last series.

Figures 8 and 9 visually describe the condition, degree, and variation of wear of the internal surface which contacted the valve stem for representative samples of Polyacrylic and Buna N seals, respectively. In Figure 8, one-half of the #3 intake seal appeared to be softened or melted from either heat or some chemical action with resultant pull out of material. One-half of #6 exhaust seal appears to have most of

the original grooving worn away. In Figure 9, the lower one-fourth to one-third of the internal surface of all seals appears to be worn smooth and appears to slightly exceed the wear in the same area of the P.A. seals.

Bench test leakage for both types of seals is listed in Charts I and II. It is interesting to note that the overall average leakage for the P.A. seals (Chart I) is within the design figure for new seals and is less than the average figures for either the Buna N or lower modulus P.A. seals run in the first test series (see Charts I and II of the previously cited reports). The difference in the average bench test leakage prior to testing between Buna N and either of the two P.A. materials might be attributed to the fluoride treated surface of the Buna N.

Figures 10 through 13 illustrate the valve deposits for units 145 and 148 on which Polyacrylic and Buna N seals operated. The intake valve deposits were weighed in order to obtain a more accurate comparison since visual comparison can be deceiving because of difficulty of adequately illustrating contrasts either by colors or geometry. See Figure 14 for the deposit weight comparison. It should be pointed out that all comparisons are after conclusion of the entire test and that some of the deposits accumulated during the last 10,000 mile interval during which OEM seals operated on both engines. However, it might be reasonable to assume that equal deposits would accumulate in both engines as a result of use of the same type seal in both engines.

Axial load-deflection measurements were made of all seals before and after testing. The instantaneous plot of measurements resulted in hysteresis curves as shown in Figures 15, 16 and 17. Figure 15 represents

the #5 intake seal made from Buna N material for both the new and used conditions. Figure 16 represents the #5 intake seal made from the high modulus Polyacrylic compound. Comparison of Figure 16 with 15 illustrates the difference between the more plastic-like characteristic of Polyacrylic with the true, rubber-like bounce and snap of Buna N. Figure 17 is a comparison between the high modulus Polyacrylic seals run in this test series and the lower modulus Polyacrylic seals run in the first series. Charts III and IV list the quantitative results of the load deflection measurements for seals run in this series. These results are not completely understood especially when compared with the same measurements in the first test series. A complete explanation of this type measurement and the results obtained from both of these test series is beyond the scope of this report and should be reported separately.

Charts V and VI summarize the valve stem and guide bore wear for both engines. Unlike the first series of tests, higher guide wear was not accompanied by lower stem wear and vice versa in this series. Chart V reveals that maximum exhaust guide wear of .006" occurred in two cylinder locations. Average wear was .0028". Intake guide wear was one-fourth this amount. This may not be excessive for 60,000 miles but it is greater than the amount experienced in the first series. Exhaust stem wear in both engines was three times the amount which occurred in the first series. Contact with Chevrolet Engineering people at a valve seal slide presentation (late in 1966) revealed that variations can occur in cylinder heads as a result of differences in process between machining plants. They reported that even guide bore finish can be different. With such unknown factors prevalent, it is difficult to establish meaningful absolute values.

With reference to Charts I and II, it can be seen that the change which occurred in the average valve stem finish for all valves was almost 60 percent of the original value whereas this same change in the first series of tests was about 75 percent of the original value. The magnitude of change was much less for this second series and the final value was at a slightly higher level.

The one exhaust valve failure in the #145 unit during the second series at 36,625 miles is considered to be a normal failure and one to be expected under such severe operating conditions of high speed operation and heavy car weights. A similar failure occurred in the same #145 unit in the first series at 41,150 miles.

TEST PROCEDURE:

The same two ARA units (#145 and #148) with Chevrolet 283 engines were used for this second series as were run in the first series. New cylinder heads and new valves were used for both engines. The rubber materials were reversed for the second series with P.A. in the #145 unit and Buna N in the #148 unit.

Valve guide bore, stem size, and stem surface finish in the seal travel area were measured prior to and subsequent to testing. The valve seats were "touched up", guides machined for P.C. seals, and seals and valves installed in P.C. Road Test. The heads then were taken to ARA for assembly on the test engines. The engine blocks were surface-honed and thoroughly cleaned prior to build up. New original equipment pistons were used for this series.

The same ring combination was used in both engines. It was a duplicate of the set used in the first series of tests and was composed of the following:

Top cm. – 3⅞ × 5/64 Moly K Plain Compression
2nd cm. – 3⅞ × 5/64 Ferrox KTF200 compression
Oil – 3⅞ × 3/16 E-518A 17-23#

All engine work except head build up was accomplished by ARA personnel under P.C. supervision.

Seal leakage was measured on the two-valve bench test at standard conditions of 18 +" Hg vacuum, 230°F + oil temperature, and 1440 RPM cam speed. Hysteresis measurement of the rubber jackets was made on the Instron test machine owned by Kitco Engineering and Manufacturing Co. at Bluffton, Indiana.

The oil used was Texaco Advance Custom Havoline 10-W-30 and was changed at 5,000 mile intervals. The oil filter was changed each 10,000 miles and the air cleaner was serviced at this same mileage. Spark plugs were changed each 15,000 miles. Fuel was Texaco regular.

The cars were especially weighted to produce a gross vehicle weight of between 4000 and 5200 pounds distributed evenly on the wheels for tire testing. During approximately 40,000 miles, both cars were operated on a prescribed open highway course and accumulated at least 1,000 miles per day of 20 hours. The balance of 20,000 miles accumulated at 850 miles per day of 16 hours on an eight mile oval test track. Mileage on the road course and the track was alternated as follows: Unit #145 – road 9,800 miles, track 15,600, road 16,900, track 4,700, road 13,500; Unit #148 – track 3,400 miles, road 7,800, track 16,200 and road 32,600. Both engines were run on a 300 mile break-in schedule of one hour each at speeds of

25-35 mph, 35-45, and 45-55 and 1½ hours each at speeds of 55-65 mph and 65-75.

After 50,000 miles on both units, the all-rubber seals were removed and replaced by original equipment seals for these engines, which consisted of a rubber "O" ring in a stem groove and a metal shield surrounding the top end of the valve spring (see Figure 14, reports 757-F002, 409-F020). The cylinder heads were not removed for this seal change, but rather air was introduced into each cylinder to hold the valves closed while the seals were removed. The engines were operated an additional 10,000 miles under the new seal condition prior to complete tear down.

For the hysteresis curve measurements, all seals in the assembled state were deflected the same given amount in an axial direction on an Instron test machine in the rubber vendor's laboratory. The hysteresis curves were obtained in order to have some numerical measure of the aged condition of the rubber.

The intake valves were weighed before and after cleaning. Cleaning was accomplished by physically scraping the deposit from the valve head.

Testing started late in September 1965 and was completed in February of 1966.

DATA:

Figure 1 – Graph of engine oil economy vs. mileage
2 – Graph of engine oil economy vs. mileage accumulated average
3 – Photo of typical guide machining
4 – Eccentric guide measurements right head, ARA unit #148
5 – Eccentric guide measurements, left head, ARA unit #148

Figure 6 – Eccentric guide measurements, right head, ARA unit #145

7 – Eccentric guide measurements, left head, ARA unit #145

8 – Photo of four Polyacrylic seals sectioned to exhibit stem contact

9 – Photo of four Buna N seals sectioned to exhibit stem contact

10 – Photo of valves from left head ARA unit 145 Polyacrylic seals

11 – Photo of valves from right head ARA unit 145 Polyacrylic seals

12 – Photo of valves from left head ARA unit 148 Buna N seals

13 – Photo of valves from right head ARA unit 148 Buna N seals

14 – Graph of intake valve deposit measurements, both units

15 – Graph of load deflection characteristics typical Buna N seal

16 – Graph of load deflection characteristics typical Polyacrylic seal (high modulus)

17 – Graph of load deflection characteristics comparison between low and high modulus Polyacrylic material

Chart I – Bench test performance and measurements, ARA unit #145

II – Bench test performance and measurements, ARA unit #148

III – Rubber jacket hysteresis measurements, Polyacrylic, ARA unit #145

IV – Rubber jacket hysteresis measurements, Buna N, ARA unit #148

V – Valve guide and stem wear, ARA unit #145

VI – Valve guide and stem wear, ARA unit #148

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APPENDIX H

MAGAZINE ARTICLE

[*REPRODUCED FROM* RUBBER AGE, OCTOBER, 1961; PP 99-101]

Slippery Rubber

– BY C. M. DOEDE –
President, Quantum, Inc. – Wallingford, Connecticut

Promising research now being carried on to develop a high lubricity rubber for military uses also evinces a bright future for numerous commercial applications

IN most applications, the high coefficient of friction of rubber is a useful property, as important, or nearly as important, as rubber's elasticity. In some uses, however, elasticity is the primary requirement and a high coefficient of friction is a negative factor.

An example is the O-ring used to create a fluid-tight seal around a rotating shaft. Here the need is for a material that will press tightly against the shaft and that has the resilience to conform to the shaft's shape, even in the face of imperfections and deformations. Friction has no useful function in an O-ring and only leads to wear and deterioration of the seal.

In most cases, of course, the fluid to be retained is a liquid that has lubricating properties, so that friction is radically reduced, but any friction in a shaft seal is detrimental to its service life. Also, there is always danger of loss of the lubricant, with rapid wear, destruction of the seal, and impairment of the mechanism as the likely consequence. In addition, in certain systems it may be necessary to retain a gas, in which case

special provisions must be made for lubricating O-rings or other packings. Ideally, all such seals should be able to function for long periods of time without any applied lubricants, both as insurance against damaging wear and as a safeguard to the mechanism in the event that the lubricant is lost. A rubber or elastomeric material with a very low coefficient of friction is obviously called for as an approach toward this ideal.

As soon as one envisions a rubber with a low coefficient of friction as a speculative possibility, he immediately foresees other potential uses for such a material. A "frictionless" rubber, for instance, should be an excellent material for ball and plug valves. Possibly, friction is the greatest cause of leaky household faucets and all the attendant nuisance repairs. Certainly, a sizable market would immediately exist if one could come up with a near-frictionless faucet valve washer and valve stem packing that had ample resilience to insure closure. Also a "frictionless" — or to put it more accurately, a high-lubricity — rubber should have use as a light-duty bearing and should have advantages over plastic bearings in applications where the self-alignment and vibration-damping qualities made possible by the elasticity of rubber are beneficial factors.

Then, merely by extension of thinking one can foresee tonnage use for low-friction elastomers as weather seals for windows and doors and as extruded or molded strips for sliding window and panel closure retention and sealing. Hermetically tight windows

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The Research Problem

"The goal should be retention of the base composition to assure elasticity, tensile strength, and tear resistance, but development of lubricity as an integral, molecular feature of the surface."

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would be possible if the window units slid over a strip of highly elastic, yet near-frictionless rubber. The principle would also make possible non-stick static seals, such as hatch and bulkhead gaskets.

Many attempts have been made to develop a low-friction rubber. Usually these have involved incorporating some lubricating material into the base composition or the coating of the elastomer with a lubricant. Adding graphite, molybdenum disulfide, Teflon, or oils to the composition leads to disappointing results, mainly because sufficient additive to sustain the lubrication function causes gross loss of physical properties — reducing, for instance, tear and tensile strengths and elasticity. Similarly, superficial coatings of lubricants, such as Teflon dispersions and graphite, are quickly lost, and thus give only temporary reduction in the friction coefficient. Elastomers with superficial coatings also can have only very limited use, since they are messy to handle and unacceptable wherever soiling is a consideration.

As a result of its work with various elastomers and plastics, Quantum, Inc., became cognizant of the need for a low-friction, high-elasticity material and conceived the idea of creating a truly "slippery" rubber by a chemical surface treatment. It seemed obvious to us that the goal should be retention of the base composition to assure elasticity, tensile strength, and tear resistance, but development of lubricity as an integral, molecular feature of the surface. A way to accomplish this, we reasoned, would be to perfluorinate the surface structure, so as to achieve a surface composition similar to Teflon's.

Causes of Frictional Behavior

Before describing the chemical approach used to successfully develop slippery rubber, some discussion of

the basic physical reasons for frictional behavior in elastomers and plastics may be in order. Aside from the effect of mechanical roughness, it would seem that the frictional behavior of these materials is largely due to the interaction of electrical forces between the polymer and the surface it contacts. Hydrocarbon elastomers as a class have high coefficients of frictions. Typically, the dipole forces associated with CH groups in the polymer molecule are high — as compared with CF groups — with a resultant high level of attraction between such a polymer and a contacting surface. On the other hand, perfluorinated materials exhibit lower coefficients of friction, because interatomic forces are internally balanced (low dipole moment). In demonstration of this, W. A. Zisman, of the Naval Research Laboratory, has achieved a correlation between the frictional coefficients of materials and their surface free energies. Perfluorinated materials were found to have low surface free energies and also exhibited low coefficients of friction.

Practical Applications

In practical applications, one must also consider the fact that sliding surfaces are far from smooth when considered from the standpoint of their microstructure. In the absence of film lubricants, appreciable force may be required to slide asperity over contacting asperity. This is also a factor in the coefficient of friction. Polytetrafluoroethylene functions as a low-friction material, not only because of its low surface free energy, but also because fragments of the polymer are easily torn away by micro-projections of the bearing surface, thus filling the "valleys" of the bearing surface with the polymer. Once the initial wearing away is complete, film separation of the contacting surface has been accomplished. Since the sliding action now takes place between two

perfluorinated surfaces, the surface free energy is minimized and optimum reduction in friction is realized.

The effects of fluorine in the structure of a polymer in lowering frictional properties — or more aptly, of hydrogen in increasing friction — is seen in the comparison of the coefficients of friction of rubber, Viton "A", and Teflon. Unlubricated natural rubber compounds have coefficients of friction which range from 0.8 to more than 1.0 when measured against a smooth steel surface. Viton "A", a partially fluorinated polymer with one CH_2 group in the unit structure, has a coefficient of 0.50, and Teflon, a completely fluorinated polymer, a coefficient of 0.30. The presence of the two hydrogen atoms in the Viton "A" molecular unit is possibly the most significant factor contributing to the increase in the coefficient of friction over Teflon.

From these theoretical considerations, it can be seen that the complete fluorination of the surface of rubber should give that surface a reduced coefficient of friction. The surface so produced would be chemically bonded and should have functional characteristics similar to those of Teflon. The approach envisioned by Quantum involved the following steps:

(1) Graft polymerization of chemically active monomers or oligmers to the surface of an elastomer.

(2) Subsequent conversion of the graft polymer to a fluorinated form.

The validity of this approach was demonstrated by the grafting of methyl acrylate on the surface of natural rubber, subsequent hydrolysis to the corresponding acid form, and fluorination of the acid with sulfur tetrafluoride. The use of sulfur tetrafluoride as the fluorinating agent permits controlled fluorination of

certain active chemical groups, such as COOH, and, in this instance, results in a trifluorinated terminal carbon. Ultraviolet radiation was used to activate the rubber surface during grafting, and the fluorination reaction was carried out in a pressure reactor at steam temperatures.

Frictional Characteristics

Samples of rubber sheet so treated exhibited drastic reduction in frictional characteristics. Comparative tests indicated that the coefficient of friction under

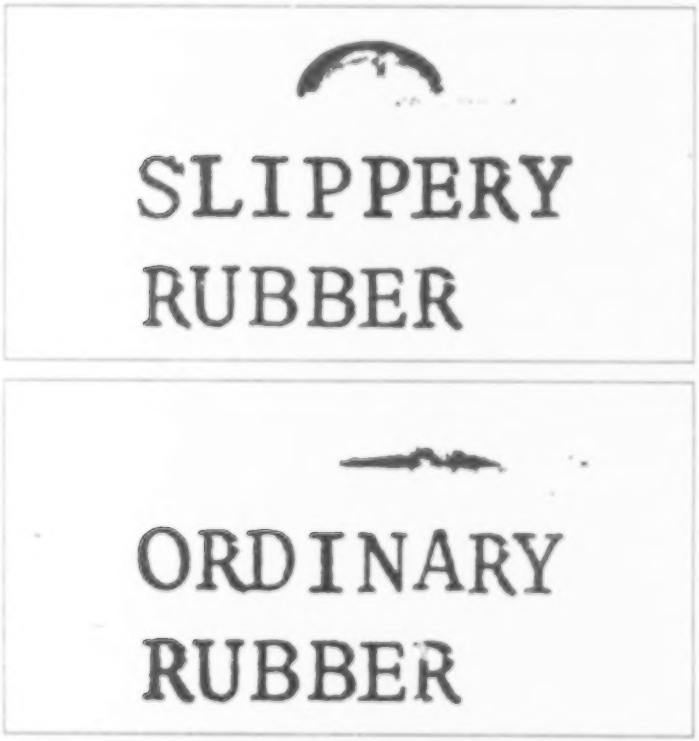

FIG. 1 – Illustrated is the difference in the contact angle of wetting by water. The contact angle for plain rubber was 78°, while the contact angle for slippery rubber was 101° (contact angle for Teflon is 104°). The contact angle and coefficient of friction are related, since both are functions of the surface free energy of the rubber.

static load had been reduced to approximately one tenth that of the control samples, and that under dynamic load the frictional coefficient of "slippery" rubber was even less. Measurement of the contact angle of water droplets on fluorinated surfaces and untreated controls of the same elastomeric material (Figure 1) yielded the following results:

Material	*Contact Angle*
Natural rubber	78°
Treated surface	101° = 5°
Teflon (literature value)	104°

A large contact angle is indicative of low surface energy, a factor, as we noted earlier, that can be correlated with low coefficients of friction (Figure 2).

FIG. 2 – The coefficient of friction is less for slippery rubber as evidenced by the smaller deflection of the spring. The spring pulling the weight over the slippery rubber is almost the same length as when unstressed.

It will be noted that these treated samples of rubber have a contact angle almost identical with that of Teflon. Anyone who has ever touched a piece of Teflon is acquainted with its high lubricity — its oily feel. Quite obviously, rubber with a Teflon-like surface, would seem to approach the ideal as a material for O-rings and other precision mechanism seals.

The U.S. Navy Bureau of Ships became interested in slippery rubber and now has a study under way at Quantum aimed at the development and production of "permanently lubricated elastomeric materials" which meet Bureau of Ships requirements for non-lubricated dynamic seal applications.

It is believed that in this research program, and in others that Quantum will undertake on diverse commercial product applications, even greater lubricity can be developed in elastomeric surfaces. Several techniques are being considered whereby the surface can be made "more fluorinated" than by the original process. In the new procedures, attempts will be made to produce surface conversion coatings containing a preponderance of $_CF_2_CF_3$ chain terminations, inasmuch as there is evidence that the CF_2 group will further enhance lubricity.

The Potential

Much work remains to be done before the many commercial advantages of slippery rubber can be fully realized. Inasmuch as thickness of the coating, resistance to fluids, physical properties, wearability, changes in dimension, cost of treatment, and other factors are influencing considerations, it is believed that slippery rubber will have to be "tailored" for most individual applications. The treatment for an aircraft engine O-ring would certainly be different from that used to

mass produce, say, valve stem packings for household water systems or extrusions for weather-stripping purposes. Also, there is much work to be done in adapting the process to such materials as neoprene, butyls, silicones, and nitrile type rubbers. Cost data will have to be developed for individual applications, and these will in part determine their feasibility.

Despite the vast amount of research to be done, and the specific requirements for individual applications, no insurmountable obstacles, either technical or economic, are seen that would prevent widespread use. Even though the chemistry is fairly sophisticated, the procedures are readily amenable to commercial production. It would seem likely that the cost of treatment would be easily recovered through the value added to the product — and that many markets now closed to rubber will be opened to elastomers with near-frictionless characteristics.